TECHNOLOGY TRANSFER THROUGH FDI IN TOP-10 TRANSITION COUNTRIES: HOW IMPORTANT ARE DIRECT EFFECTS, HORIZONTAL AND VERTICAL SPILLOVERS?

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Technology Transfer through FDI in Top-10 Transition Countries: How Important are Direct Effects, Horizontal and Vertical Spillovers?

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Abstract

The paper exploits a large set of more than 8,000 firms for ten advanced transition countries in order to uncover the importance of different channels of technology transfer through FDI and its impact on productivity growth of local firms. In addition to direct effects, we also distinguish between intra-industry (horizontal) and inter-industry (vertical) spillovers from foreign owned firms to local firms. After correcting for foreign investment selection bias and controlling for endogeneity of input demand (using a dynamic system GMM approach), direct FDI effects were found to provide by far the most important productivity effect for local firms in transition countries. Direct effects of FDI are found to provide on average an impact on firm's productivity that is larger by factor 50 than the impact of backward linkages and by factor 500 larger than the impact of horizontal spillovers.

KeyWords: Foreign direct investments, technology transfer, spillovers, transition economies

JEL Classification: D24, F14

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1 Introduction

The channels of international technology transfer and their importance for growth have been studied extensively in the 1990s. These studies identify three principal channels of international R&D spillovers. The first is a direct transfer of technology via international licensing agreements (Eaton and Kortum 1996), though recently these provide less important source as the latest and most valuable technologies are not available on license (World Investment Report 2000). Second is foreign direct investments (FDI) that provides probably the most important and cheapest channel of direct technology transfer as well as indirect, intra-industry knowledge spillovers to developing countries (Blomström and Kokko 1997). Several studies offer empirical evidence on the importance of FDI flows for firm's productivity growth in developing countries (see Aitken and Harrison 1999, Borensztein, De Gregorio and Lee 1998, Blomström and Sjöholm 1999). Third channel of technology transfer is through international trade, in particular imports of intermediate products and capital equipment (see Markusen 1989, Grossman and Helpman 1991, Feenstra, Markusen and Zeile 1992) as well as through learning by exporting into industrial countries (Clerides, Lach and Tybout 1997).

There is quite enormous empirical evidence on positive direct technology transfer from a multinational corporation (MNC) to its local affiliates in terms of higher productivity levels and growth These studies using firm level panel data include developed as well as developing countries (e.g. Haddad and Harrison 1993, Blomström 1994, Blomström and Sjöholm 1999, Aitken and Harrison 1999, Greenaway and Wakelin 2001, Berry, et. al. 2001, Alverez, et. al. 2002, Blalock 2001, etc.). On the other side, despite the theoretical justification of potential spillovers, the evidence on technology spillovers from a local affiliate to its horizontal competitors and/or to its vertically linked suppliers and customers is very weak or even negative. In an extensive review of the literature, Görg and Greenaway (2001), list three potential reasons for empirical failure of finding significant spillovers. First, MNCs might be very effective in protecting their technology advantages and so preventing from potential spillovers. Second reason is that most of the studies has been carried out at the aggregate or sectoral level, which is not an appropriate way of looking for spillovers. And third, using cross-section analysis is clearly less efficient way of accounting for spillovers as compared to panel data studies. In addition to it, there are several other reasons for failing to find evidence of spillovers. One reason is the poor quality of data and limited samples of firms studied. Second reason might be in the short panels of firms analyzed and/or in hypothesizing a linear relationship between spillovers and local firms productivity growth. Yet another reason might be lie in using inappropriate econometric techniques like simple pooled OLS or static panel data techniques.

Recently, there is also a growing literature on FDI spillovers in transition countries. However, similarly to the developed and developing countries' studies, the existing evidence from Eastern European firm-level panel data suggests that there are few intra-industry spillovers from FDI. Konings (2001) shows that FDI may be important for transferring technology to an affiliate, but provides no evidence of horizontal spillovers to local firms in Bulgaria, Poland and Romania from 1993 to 1997. Instead, there is significant evidence of negative spillovers in Poland. Djankov and Hoekman (2000) also provide evidence of negative spillovers and suggest that there may not even have been much technology transfer to the foreign affiliates in the Czech Republic from 1992 to 1996. Kinoshita (2000) provides evidence of spillovers in the Czech Republic from 1995 to 1998, but they are limited to firms engaged in R&D or in the production of electrical equipment. Damijan and Knell (2002) study the impact of different privatization methods on the accessibility of international knowledge spillovers by local firms. They find that firms in Estonia, who underwent privatization process that was very open to foreign capital, gain significant direct technology transfer through FDI, while firms in Slovenia, mainly privatized to local funds as well as to insiders (i.e. employees and managers), are constrained to access to international knowledge spillovers mainly through international trade flows. Damijan et al (2001) provide a study on eight transition countries using static panel data approach and also fail to find support for intra-industry spillovers. More recently, several studies (e.g. Schoors and van der Tool 2001, Smarzynska 2002, and Smarzynska and Spatareanu 2002) find evidence of inter-industry spillovers from FDI for individual transition countries.

These previous studies on transition economies provide a useful insight into the effects of international R&D spillovers at the firm level, but due to heterogenous methodology used they remain merely case studies. The main objective of this paper therefore is to provide a comparative study on importance of spillovers through FDI on a set of comparable countries by using a common methodology and up-to-date dynamic panel data techniques. This is the way how to achieve comparability of the results and to provide a credible insight into the importance of different channels of international technology transfer for firms in transition countries. In order to do this, the study differentiate between direct effects of FDI from the parent firm to local affiliates as well as horizontal vertical spillovers from foreign affiliates to domestically owned local firms. To calculate horizontal and vertical spillovers and to differentiate between backward and forward vertical linkages we use the methodology developed by Blalock (2001) and Damijan and Knell (2002). The importance of these different channels of technology transfer is then estimated in the framework of growth accounting approach using the unique firm level database consisting of some 8,000 firms for ten advanced transition countries in the period 1995-1999. Due to the simultanenity problem that typically arises in growth accounting approach estimated in the panel data framework, we make use of the recently developed econometric methods for dealing with dynamic panel data. Hence, we estimate augmented production function at the firm level using system general method of moments (sys-GMM) approach. In addition, we correct for potential selection bias that arises due to possibly endogenous foreign investment decisions using a generalized Heckman two-step procedure. We find that direct FDI effects are significant in five out of ten examined transition countries and that they provide by far the most important productivity spillover for local firms. On the other hand, in three countries where significant vertical spillovers are detected, the impact of backward vertical spillovers is found to be higher by factor 10 relative to horizontal spillovers. These results speak in favor of the larger importance of vertical versus horizontal spillovers from FDI.

The paper is organized as follows. Section 2 discusses sources of productivity growth in the global economy and developes theoretical model that allows for accounting different measures of spillovers at the firm level. Section 3 describes data and econometric approach employed. Section 4 discusses the results and final section concludes.

2 Channels of technology transfer through FDI

There are many ways an firm can acquire new technology besides its own investments into R&D capital. Despite trade, FDI is potentially the most important international vehicle of technology transfer for firms. This source of productivity growth has been particularly important for firms in transition economies because of the urgent need to restructure quickly. Foreign ownership often provides local firms with efficient corporate governance, as they, mainly privatized to insiders, do not have incentives to restructure (Blanchard 1997). FDI may also be the cheapest means of technology transfer, as the recipient firm normally does not have to finance the acquisition of new technology. And it tends to transfer newer technology more quickly than licensing agreements and international trade (Mansfield and Romeo 1980). And since it has a more direct effect on the efficiency of firms, it also has the potential to create positive spillover effects to local firms.

Technology spillovers through FDI can occur between firms that are vertically integrated with the MNC (inter-industry spillovers) or in direct competition with it (intra-industry spillovers). Kokko (1992) identifies at least four ways that technology might be diffused from foreign investment enterprise (FIE) to other firms in the economy: (1) demonstration - imitation effect, (2) competition effect, (3) foreign linkage effect, and (4) training effect. Not all spillovers are positive as FDI can generate negative externalities when foreign firms with superior technology force domestic firms to exit. These negative externalities are often called also competition effect, crowding-out effect or business-stealing effect.

Recent analyses of importance of technology transfer and spillovers through FDI are typically carried out using firm panel data. As mentioned above, the evidence provides support for direct technology transfer from MNCs to their affiliates, while there is only a weak evidence of spillovers to indigenous firms.

However, with the very recent exceptions of Blalock (2001), Schoors and van der Tool (2001), Smarzynska (2002) and Smarzynska and Spatareanu (2002), all of the studies have focused on intra-industry spillovers. Aitken and Harrison (1999) show significant technology transfer to the affiliates and some positive spillovers to domestic firms in Venezuela located close to the affiliate, but there were also negative spillovers to the domestic economy as a whole. There was some positive spillovers in other developing countries, but these were limited to certain industries, such as those with relatively simple technology in Morocco (Haddad and Harrison 1993), are export oriented as in Indonesia (Blomström and Sjöholm 1999), or have sufficient human capital as in Uruguay (Blomström 1994). Earlier studies that did not use panel data often found evidence of intra-industry spillovers. These include a study by Caves (1974) of Australian manufacturing in 1966, a study by Globerman (1979) of Canadian industry in 1972 and studies of Mexico in the mid-1970s by Blomström and Persson (1983) and the mid-1980s by Blomström and Wolff (1994). However, a study of US firms in Europe shown that spillovers were localized and that competition forced many local competitors out of small markets (Cantwell, 1989). Recent analyses of panel data for advanced countries provide little or no evidence of spillovers in the 1990s. Girma, Greenaway and Wakelin (2001) provide evidence for the United Kingdom, (Berry, et. al. (2001), for Ireland, and Alverez, et. al. (2002) for Spain. There was also some evidence of negative spillovers in Ireland.

On the other hand, empirical evidence (Kokko 1994, Borensztein, De Gregorio and Lee 1998, and Kinoshita 2000) demonstrate that FDI can contribute to overall domestic productivity growth only when technology gap between domestic and foreign firms is not too large and when a sufficient absorptive capacity is available in domestic firms. In other words, technology spillovers from MNCs tend to occur more frequently when the social capabilities of the host country and the absorptive capacity of the firms in the economy are high. While relatively backward countries have a certain advantage in catching-up, it becomes increasingly more difficult for the country to build the necessary social capabilities and absorptive capacities that allow firms to take advantage of the technology spillovers that are available in the economy. For this reason, R&D can be thought of as having two complementary effects on firm's productivity growth (Cohen and Levinthal 1989). First, R&D directly expands firm's technology level by new innovations, which is called innovation effect. On the other hand, it increases firm's absorptive capacity - ability to identify, assimilate and exploit outside knowledge, which is usually called learning or absorption effect. These two important effects have to be included into a serious investigation of spillovers through FDI.

Very recently, empirical studies take explicit account of the vertical spillovers. Blalock (2001) developes a methodology for calculating backward and forward linkages between foreign owned firms and local firms. He finds positive vertical spillovers for Indonesia. Accordingly, Smarzynska (2002) finds positive backward spillovers for Lithuania, and Schoors and van der Tool (2001) find positive vertical spillovers in Hungary. In contrast, Smarzynska and Spatareanu (2002) detect negative vertical spillovers in Romania. Hence, these studies suggest that vertical supply chains rather than intra-industry spillovers provide a channel of technology spillovers between foreign afiliates and local firms.

3 Modeling direct and spillover effects of FDI

As indicated by the above discussion, empirical studies on technology spillovers should differentiate between direct effects of FDI as well as horizontal and vertical spillovers. In the search for horizontal spillovers, one should account for the technology gap between foreign affiliates and local firms, while the analysis of vertical spillovers should differentiate between backward and forward linkages induced by foreign affiliates.

Recent studies on technology transfer and spillovers through FDI are typically carried out using firm level panel data. The impact of external technology spillovers can be measured indirectly in a production function approach by considering the Sollow residual of output growth as the rate of technological change after subtracting off the growth rates of labor and capital. But this residual may be more a measure of ignorance than a measure of technological accumulation as Abramovitz (1956) pointed out. An alternative way is to include the technology variables directly in the production function, a method more reminiscent of the endogenous growth models developed since the late 1980s. This approach provides a way to study the various factors that affect productivity growth, including the technological accumulation. This is done by using the growth accounting approach and decomposing total factor productivity (TFP) into factors internal and external to the firm, such as R&D activity, human capital and channels of technology transfer.

Following Basu and Fernald (1995), we assume each firm has a production function for gross output:

$$Y_{it} = H^i \left(K_{it}^{\alpha}, L_{it}^{\beta}, N_{it}^{\gamma}, T_{it} \right), \tag{1}$$

where $Y_{it}$is gross output in firm i at time t, and K_{it}, L_{it}, N_{it}, and T_{it} represent the capital stock, the number of employees, materials used in production, and technology, respectively. The production function (1) is homogenous of degree r in K, L and N, such that $r = \alpha + \beta + \gamma \neq 1$, which implies that H^i may have non-constant returns to scale. We include materials used in production because of measurement problems in K, which, typically for former socialist countries, arise due to the poor accounting standards and the tendency to understate the value of capital due to the management and worker buy-out methods of privatization.

Differentiating equation (1) with respect to time, we get:

$$y_{it} = \alpha k_{it} + \beta l_{it} + \gamma n_{it} + t_{it} \tag{2}$$

where small letter variables indicate logarithmic growth rates of K, L, N and T, and α, β and γ represent the elasticity of output with respect to k, l and n. We assume that technology shock t is a function of internal technology variables $\mathbf{G}_{it}$ and of various spillover effects $\mathbf{Z}_{it}$:

$$t_{it} = f^{i}\left(\mathbf{G}_{it}, \mathbf{Z}_{it}\right) \tag{3}$$

where

$$F_i, M_i, RD_{it} \in \mathbf{G}_{it}$$
$$ES_{it}, HS_{it}, VS_{it}^{B}, EX_{it}, IM_{it} \in \mathbf{Z}_{it}.$$

where the elements of $\mathbf{G}_{it}$ are foreign ownership F_i, majority foreign ownership M_i, and internal R&D expenditures (RD_{it}) of a firm. $\mathbf{Z}_{it}$ consists of potential home market spillovers (external economies of scale at the industry level) ES_{it}, horizontal spillovers HS_{it} and of vertical backward spillovers VS_{it}^{B} as well as of global knowledge spillovers through international trade (EX_{it} and IM_{it} stand for firm's exports and imports, respectively).

The basic idea underlying equation (3) is that individual firm can boost its technology level either internally through appropriate ownership structure and own investments into R&D and/or by relying on external sources of knowledge spillovers, such as home market spillovers, horizontal and vertical spillovers from affiliates of MNC's as well as learning-by-exporting and imports of capital and intermediate goods.

Regarding the impact of FDI, MNC's can transfer newer technology and organizational skills both directly to the affiliate, and indirectly to other firms in the host economy. On one hand, direct effects generally appear to affiliates as changes in productivity (shown in H^i) and in better utilization of existing inputs (accounted directly in foreign affiliates by introducing interaction terms $F_{it}k_{it}$, $F_{it}l_{it}$ and $F_{it}n_{it}$ into model (2)). Presence of an affiliate, on the other hand, can also increase the rate of technical change and technological learning in the economy indirectly through knowledge spillovers to local firms. Knowledge spillovers occur as a consequence of affiliate introducing new technologies and organizational skills that are typically better than in the local firms. The innovation system and social capabilities of the host economy, together with the absorptive capacity of other firms in the host economy measured by own R&D investments (RD_{it}), will then determine the pace of technological progress in the economy as a whole.

Knowledge spillovers can occur between firms that are vertically integrated with the foreign affiliate (inter-industry spillovers) or in direct competition with it (intra-industry spillovers). Kokko (1992) and Perez (1998) describe at least five ways how knowledge spillovers from foreign affiliates can increase technical change and technological learning. First, competition with the foreign affiliate can increase intra-industry spillovers by stimulating technical change and technological learning. Greater competitive pressure faced by local firms induces them to introduce new products to defend their market share and adopt new management methods to increase productivity. This kind of spillover, known as "competition effect", is most important in industries with relatively low actual and potential competition and high barriers to entry. Second, cooperation between foreign affiliates and upstream suppliers and downstream customers increases knowledge spillovers (vertical spillovers). To improve the quality standards of their suppliers, foreign affiliates often provide resources to improve the technological capabilities of both vertically and horizontally linked firms. Third, human capital can spill over from foreign affiliates to other firms as skilled labor moves between employers. These spillovers are especially important for firms that lack the technological capabilities and managerial skills to compete in world markets. Fourth, the proximity of local firms to foreign affiliates can sometimes lead to demonstration or imitation spillovers. When foreign affiliates introduce new products, processes and organizational forms, they provide a demonstration of increased efficiency to other local firms. Local firms may also imitate foreign affiliates through reverse engineering, personal contact and industrial espionage. Finally, a concentration of related industrial activities may also encourage the formation of industrial clusters, which further encourage FDI and local spillovers.

Although there are clear differences between these types of knowledge spillovers, the empirical literature captures mainly those occurring between firms within the industry. The reason is that competitive effects within an industry are much easier to measure than linkage effects across industries. Studies that estimate spillover effects using the production function approach similar to the one specified in equation (1) unintentionally pick up inter-industry effects contained in the variables Y and N. But with exception of Blalock (2001), Schoors and van der Tool (2001), and Smarzynska (2002), all of the panel data analyses on the effect of knowledge spillovers on productivity growth consider only intra-industry effects. In the present study we follow Blalock (2001) and slightly modify his methodology in order to capture these inter-industry effects by incorporating direct requirements coefficients derived from the input-output accounts from each country into the empirical model.

To disentangle the two spillover effects, we define the scope for intra-industry spillovers, or horizontal spillovers, as the share of an industry's output produced by the foreign affiliates:

$$HS_{kt} = \frac{\sum_{i=1}^{n} FA_{ikt}}{\sum_{i=1}^{n,m}(FA_{ikt} + DF_{jkt})} \tag{4}$$

$$i = 1, ..., n, \qquad j = 1, ..., m$$

where HS_{kt} is horizontal spillovers in industry k in period t, FA_{ikt} is output of foreign affiliate i in industry k and period t, and DF_{jkt} is output of domestic firm j in industry k and period t. These spillovers reflect mainly the competitive pressures that encourage local firms to introduce new products to defend their market share and adopt new management methods to increase productivity. Imitation, reverse engineering, personal contact and industrial espionage may also be captured by this variable. However, exports often comprise a large proportion of the output of foreign affiliates, reducing the impact they might have had on the domestic market. To compensate for this reduction of competitive pressures in the domestic market, we correct the measure of horizontal spillovers in (4) by the share of exports of foreign affiliates EX_{ikt} in their total output Y_{ikt}:

$$\overline{HS}_{kt} = \frac{\sum_{i=1}^{n} FA_{ikt}}{\sum_{i=1}^{n,m}(FA_{ikt} + DF_{jkt})} * \left(1 - \sum_{i=1}^{n} \frac{EX_{ikt}}{Y_{ikt}}\right) \tag{5}$$

In the next step we account for potential vertical spillovers of foreign affiliates, i.e. for the impact of foreign affiliates on their upstream suppliers.[1] Foreign affiliates often provide resources to improve the technological capabilities and quality standards of their upstream suppliers. We account for these backward linkages VS_{kt}^{B} as a sum of output of industries r purchased by firms in the industry k weighted by the share of total foreign output HS_{kt}:

$$VS_{kt}^{B} = \sum_{r,k=1}^{p} (\alpha_{krt} * HS_{kt}) \tag{6}$$

$$r, k = 1, \ldots, p,$$

where α_{krt} $(0 \leq \alpha_{krt} \leq 1)$ is the proportion of industry's r output consumed by industry k. These direct input requirements are obtained from the input-output accounts. Again, foreign affiliates tend to purchase a larger proportion of their inputs abroad than domestic firms, hence reducing the actual demand for home intermediate goods. Therefore, the measure of backward linkages in (6) should be corrected by the foreign affiliates' import share:

$$\overline{VS}_{kt}^{B} = \sum_{r,k=1}^{p} \left(\alpha_{krt} * HS_{kt} * \left(1 - \sum_{i=1}^{n} \frac{IM_{ikt}}{MC_{ikt}}\right)\right) \tag{7}$$

where IM_{ikt} and MC_{ikt} are imports and material costs of foreign affiliate i.

It is important to note that not all spillovers are positive. The parent firm can also have a negative impact on the direct transfer of technology to its affiliate and reduce the knowledge spillovers to the local economy. For example, MNC's can provide their affiliates with too few, or the wrong kind of technological capabilities, or even limit access to the technology of the parent company. This type

[1] In this paper we account for backward linkages only, i.e. for the impact of foreign affiliates on their upstream suppliers. Similarly, foreign affiliates can also provide technical assistance to their downstream customers. However, as foreign affiliates are mainly engaged in end-user consumer goods, these forward linkages are quite low. This is the reason why we neglect this issue in the present study.

of behaviour may restrict the production of its affiliate to low-value activities and can also reduce the scope for technical change and technological learning both within the affiliate and as spillovers to the domestic economy. Even if the parent firm transfers new technology to its affiliate, it can reduce the scope for knowledge spillovers by limiting downstream producers to low value added activities or eliminate them altogether by relying on foreign suppliers (including itself) for higher value added intermediate products. Domestic firms that don't have the capability to adapt can also be crowded-out of the market. Bardham (1998) also suggests that the parent company can restrict domestic production when they set up affiliates with the main purpose of protecting existing property rights and taking out patents in the host country.

4 Data and econometric approach

4.1 Data

Data at the firm level provide the best way to test for productivity spillovers. In order to analyze the importance of different channels of technology transfer in a comparative way we gathered panel data for ten most advanced transition economies. The data on balance sheets and financial statements were collected for the period 1995-1999 for most of the countries, while for Estonia and Slovenia the database is for the period 1994-1998 and 1994-1999, respectively. For Estonia and Slovenia data were obtained from local Statistical offices, while for other transition countries source of data is the Amadeus database. Our database consists of manufacturing firms with more than 100 employees (for Slovenia the lowest bound of 10 employees is applied). Data on labor enters our estimations as a number of employees, which is calculated from effective hours worked, while data on sales, capital and intermediates is taken in local currencies. Capital data were deflated using GDP deflators, while data on sales and intermediates were deflated using NACE-2 digit producer price indices for each country. We maintain balanced samples for all countries. As consequence, due to different firm data coverage and different quality of the source data, the size of samples differs significantly across countries. The poorest coverage of firms is for Slovakia, Latvia and Lithuania (from 150 to 190 firms). For Hungary and Estonia the firm coverage is only slightly better (360 - 370 firms), while for Bulgaria, Czech Republic, Poland, Romania and Slovenia firm coverage is quite good (between 1100 and 1700 firms).

Insert Table 1

We dispose with the data on the share of foreign investors in total equity of domestic firms. According to other studies, foreign ownership variable is constructed as a dummy variable F_i equal to 1 when the share of foreign equity in total capital of a domestic firm exceeds 10 per cent, and zero otherwise. In addition, many theoretical papers on FDI claim that the extent of foreign ownership matters. Hence, an additional dummy variable M_i has been included into the model in order to differentiate between minority and majority owned foreign affiliates (M_i is equal to 1 when the share of foreign equity in total capital of a domestic firm exceeds 50 per cent, and zero otherwise). This is to find out whether majority foreign ownership facilitates transfer of more complex technology and managemnt skill to local firms.

Share of FIEs in total number of firms in our panels ranges between 3 and 30 per cent, with average foreign penetration amounting to 14 per cent. As revealed in Table 1, the aggregate shares of FIEs in total employment of individual transition economies exceed the shares of FIEs in total number of firms by 70 per cent on average. On the other side, the aggregate shares of FIEs in total sales exceed their shares in total number of firms by threefold. This indicates that FIEs are not only larger relative to domestic firms in terms of employment and output, but also that FIEs are more more efficient in terms of labor productivity. In addition, breakdown of the above figures by individual manufacturing sectors reveals greater concentration of FIEs in more capital and skill intensive sectors. Another interesting fact can be seen from the figures on R&D accumulation by foreign and domestic firms. It is a matter of fact that R&D activities are basically concentrated in foreign firms, with FIEs' share in total R&D expenditure amounting to 37 per cent. The only exception being probably Slovenia, where local firms seem to lay emphasis on R&D accumulation in the same manner as FIEs do. This may have important implications for the autonomous innovative ability of domestic firms and their absorption capacity for potential R&D spillovers in the economy in both groups of countries.

Data on input - output accounts stem from local statistical offices. These data conducted at NACE-2 digit level refer mainly to years 1996 or 1998. Unfortunately, these input - output tables are not available at a more disaggregated level and for all years in our sample. This of course limits our potential to discover possible vertical spillovers as these are normally taking place at a lower level of disaggregation as well as we are forced to exclude dynamic changes in the structure of studied economies. However, there is nothing one can do about it.

4.2 Correction for sample selection bias

Having in mind the above discussed differences in characteristics between foreign and domestic firms, one can argue that our panels of firm data might suffer under selection bias. This is due to the fact that foreign investment decisions are not randomly distributed but are probably subject to firms' characteristics and their initial performances. Hoekman and Djankov (2000) as well as Evenett and Voicu (2001) claim that foreign investors tend to acquire shares in largest and most successful domestic firms. For Slovenia, the opposite trends can be claimed, where FDI are shown to be directed into less effcient firms (see Rojec et al 2001). Hence, treating foreign and domestic firms as homogenous units of observation will likely produce biased results due to possible endogeneity of foreign investment decisions. We deal with this problem using the Heckman two-step method proposed in Heckman (1979).[2] In the Heckman procedure, the bias that results from using non-randomly selected samples is dealt with as an ordinary specification bias arising due to omitted variables problem. Heckman proposes to use estimated values of the omitted variables (which when omitted from the model give rise to the specification error) as regressors in the basic model. Hence, in the first step we account for the probability p_i [0, 1] that a firm's selection for FDI is conditional on its initial structural characteristics before the take over. The following probit equation has been estimated:

$$\Pr(p_{it_0} = 1 \mid \mathbf{X}_{i,jt_0}) = S\left(\mathbf{X}_{it_0} \neq \mathbf{X}_{jt_0}\right) \tag{8}$$

where i and j $(i = 1, ..., n, \quad j = 1, ..., m)$ are indicating individual foreign and domestic firm, respectively. The error terms are assumed to be IID and normally distributed, thus $S(\cdot)$ is a cumulative distribution function of the standard normal distribution. $\mathbf{X}_{i,jt_0}$ is a matrix of firms' structural characteristics in the initial year. These are individual size, capital, skill and labor intensity, labor productivity as well as industry characteristics, such as size of the industry. Due to data limitation on ownership changes within the observed period, we are forced to assume unchanged ownership over the whole period, whereby we took firms' structural characteristics in the first year of our sample as their initial characteristics. In order to avoid autocorrelation, the first year's observation are then excluded from the second stage estimations. The results of a first stage probit estimations contained in Table 2 do in fact confirm the existence of selection bias in our database. The results, however, do not confirm the hypothesis that MNCs tend to acquire shares in largest and most successful local firms as pointed out by Evenett and Voicu (2001) for Czech republic. Our results suggest that size and labor productivity are not decisive firm's characteristics considered by foreign incestors. Size is not significant in any of the analyzed countries, while labor productivity is found to be a significant determinant of foreign investment decisions in only two countries. Instead, MNCs were found to tend to acquire more capital and skill intensive firms, which is confirmed for 7 out of 10 transition countries. On the other side, the tendency of foreign investors to cluster in industries with already high foreign penetration in terms of foreign ownership is confirmed for all of the ten economies. This pattern of clustering in specific industries might well be the reason in previous studies for failing to find significant horizontal spillovers. This, in turn, may also lead to significant backward spillovers if FIEs create strong demand for intermediates of other vertically linked industries.

[2] Problem of sample selection bias has been extensively dealt with in the econometric literature (see also Amemiya 1984 and Wooldridge 2002 for excellent surveys of the literature and correction methods).

Insert Table 2

Based on these probit results, the so-called inverse Mill's ratios, Λ_i, for all observations (for non-zero as well as zero observations regarding foreign investment choices) are calculated. A vector of Λ_i is then included in our second step estimations as an additional independent variable which controls for the unobserved impacts of foreign investment decisions.

4.3 Econometric approach

To analyze the impact of different channels of technology transfer on firm's total factor productivity (TFP) we estimate growth model (2) augmented by firm's technology structure (3). Using OLS approach to estimate the firm's productivity, however, is inappropriate as inputs k_{it}, l_{it} and n_{it} are probably determined endogenously by firm's past productivity (see Grilliches and Mairesse 1995). The OLS estimator is unbiased and consistent only when all explanatory variables are exogenous. This, however, is not the case in our model due to possible endogeneity between productivity and investments into inputs. Note that so far, with the exception of Smarzynska (2001), Konings (2002) and the present study, none of the studies on spillovers has taken this endogeneity problem explicitly into account. There are basically two common methods used for correcting for this endogeneity problem. Olley and Pakes (1996) suggest to use semiparametric estimation of production function in order to obtain consistent parameters on inputs. Smarzynska (2001) has recently applied this approach to the Lithuanian data. Another approach is suggested by Arellano and Bond (1991, 1988), Arellano and Bover (1995) as well as Blundell and Bond (1998, 1999), who suggest to estimate a dynamic version of the production function and then correct for endogeneity using general method of moments (GMM) in a dynamic panel data framework. Konnings (2002) has recently used a difference GMM estimation approach to firm level data on Bulgaria, Poland and Romania. In the present paper we use a system GMM estimator suggested recently by Blundell and Bond (1998, 1999), which proved to be more efficient compared to the difference GMM estimator.

In what follows we use the Blundell and Bond (1999) approach, according to which our growth model (2), can be rewritten in econometric form as:

$$y_{it} = \alpha k_{it} + \beta l_{it} + \gamma n_{it} + t_{it} + \delta_t + (\eta_i + \nu_{it} + m_{it}) \tag{9}$$

with the assumption about the error term:

$$\nu_{it} = \rho \nu_{it-1} + e_{it}$$

$$e_{it}, m_{it} \sim \mathrm{MA}(0)$$

where t is a productivity (technology) shock as specified in (3), and δ_t is a year specific intercept. The error term is decomposed into η_i which is an unobserved firm-specific effect, ν_{it} is an autoregressive (productivity) shock, and m_{it} represents serially uncorrelated measurement error. Note that both labor l, capital k and intermediates n are potentially correlated with firm-specific effects η_i as well as with both productivity shocks e_{it} and measurement errors m_{it}.

As argued above the model (9) captures dynamic processes in the firm as inputs are probably determined endogenously by firm's past productivity, and vice versa. The time dimension of panel data enable us to capture these dynamics of adjustment directly by inclusion of lagged dependent as well as lagged independent variables. Hence, a dynamic version of the growth model (9) can then be written as:

$$\begin{aligned} y_{it} &= \rho y_{it-1} + \alpha k_{it} - \rho\alpha k_{it-1} + \beta l_{it} - \rho\beta l_{it-1} + \gamma n_{it} - \rho\gamma n_{it-1} \\ &+(\theta t_{it} - \rho\theta t_{it-1}) + (\delta_t - \rho\delta_{t-1}) + \eta_i(1-\rho) + e_{it} + (m_{it} - \rho m_{it-1}) \end{aligned} \tag{10}$$

In the above specification of the model we deal with the perfect simultaneity as not only present and lagged dependent variables are correlated, but also lagged dependent variable (sales) are assumed to be correlated with present independent variables (inputs), and vice versa. Applying OLS estimator to the model specification (10) would inevitably lead to inconsistent and biased coefficients. The OLS estimator is unbiased and consistent when all explanatory variables are exogenous and are uncorrelated with the individual specific effects. This, however, is not the case in our model, which includes lagged variables. One can show that the OLS estimator will be seriously biased due to correlation of the lagged dependent variable with the individual specific effects as well as with the independent variables. This is due to the fact that y_{it} is a function of η_i in (9), and then y_{it-1} is also a function of η_i. As a consequence, y_{it-1} is correlated with the error term, which renders the OLS estimator biased and inconsistent, even if the ν_{it} and m_{it} in (9) are not serially correlated. This holds also whether the individual effects are considered fixed or random (see Hsiao 1986, Baltagi 1995, Wooldridge 2002). There are several ways of controlling for this unobserved heterogeneity and simultaneity. One way is to include exogenous variables into the first-order autoregressive process. This, in turn, reduces the bias in the OLS estimator, but its magnitude still remains positive. Another way of controlling for the simultaneity is to apply the Anderson-Hsiao instrumental variable approach. We may first-differentiate our model (9) in order to eliminate η_i, which is the source of the bias in the OLS estimator. Then we may take the second lag of the level y_{it-2} and the first difference of this second lag Δy_{it-2} as possible instruments for Δy_{it-1}, since both are correlated with it ($\Delta y_{it-1} = y_{it-1} - y_{it-2}$) but uncorrelated with the error term Δu_{it} ($= u_{it} - u_{it-1}$). This approach, though consistent, is not efficient since it does not take into account all the available moment conditions (i.e. restrictions on the covariances between regressors and the error term).

Hence, a natural choice of approach that allows for controlling for the unobserved heterogeneity and simultaneity in (10) is the application of GMM (general method of moments) estimators. There are two possible choices of application of the GMM approach to dynamic panel data. Difference GMM (diff-GMM) method uses lagged levels as instruments for first-differenced equation. However, as shown by Arellano and Bover (1995), lagged level instruments used in diff-GMM approach are weak instruments for first-differenced equation. Arellano and Bond (1998), and Blundell and Bond (1998, 1999) suggest that an application of the system GMM (sys-GMM) estimators is a more appropriate approach to dynamic panel data than using diff-GMM estimators. If model is estimated in first differences, corresponding instruments for Δx_{i3} are x_{i1} and Δx_{i1} (where x stands generally for all included variables), and so on for higher time periods. This approach allows for a larger set of lagged levels' and first-differences' instruments and therefore to exploit fully all of the available moment conditions. Hence, the system GMM approach maximizes both the consistency as well as the efficiency of the applied estimator. The only drawback of the sys-GMM approach to dynamic panel data is that either balanced panel data or longer time series are required since the first two years of observations are used up as instruments.

5 Results

In this section we first present estimation results on direct effects as well as horizontal and vertical spillovers from FDI obtained from the sample of foreign affiliates and local firms. In the second step we then account for the innovation capability and absorption capacity of local firms for taking advantage of the spillovers that are around in the economy.

In our first model we account for direct effects as well as horizontal and vertical spillovers from FDI. In effect, combining (10) and (3), we estimate following empirical model as our model 1:

$$\begin{gathered} y_{it} = \rho y_{it-1} + \alpha k_{it} - \rho\alpha k_{it-1} + \beta l_{it} - \rho\beta l_{it-1} + \gamma n_{it} - \rho\gamma n_{it-1} \\ + \pi F_i k_{it} - \rho\pi F_i k_{it-1} + \psi F_i l_{it} - \rho\psi F_i l_{it-1} + \omega F_i n_{it} - \rho\omega F_i n_{it-1} \\ + \kappa F_i + \mu M_i + \varepsilon ES_{it} + \chi HS_{it} + \upsilon VS^B_{it} \\ + \lambda\Lambda_{it} + (\delta_t - \rho\delta_{t-1}) + e_{it} + (m_{it} - \rho m_{it-1}) \end{gathered} \tag{11}$$

Our model (11) is estimated in log first differences in order to obtain estimates of coefficients on firm's TFP growth as well as to eliminate unobserved firm-specific effects η_i. As it can be seen from equation (11), our empirical model includes among dependent variables also the interaction terms $F_{it}k_{it}$, $F_{it}l_{it}$ and $F_{it}n_{it}$ in order to control for different efficiency of FIEs in utilizing their resources.

A vector of inverse Mill's ratios Λ_i is included as an additional independent variable which controls for the unobserved impacts of foreign investment decisions. The model is estimated on a set of foreign affiliates and domestic firms. In econometric estimations we apply sys-GMM approach, which in addition to lagged levels uses also lagged first-differences as instruments for equations in levels.

Before we turn to the estimation results a few words should be spent on the scope for horizontal as well vertical spillovers. Previous studies mainly failed to find evidence on horizontal spillovers. There are several possible reasons for these unsatisfactory results. First reason is substantial as, obviously, MNCs might be very effective in protecting their technology advantages and so preventing from potential spillovers. hence, there is in fact no scope for spillovers to local firms in the same industry. Another reason may lie in the empirical approach applied so far. All of the studies account for horizontal spillovers by applying linear relationship between foreign penetration of the industry (in terms of total sales of foreign affiliates) and productivity growth of local firms in that industry. One may argue, however, that there is a non-linear relation between the two. In other words, one may emphasize that with low foreign penetration of the industry the scope for horizontal spillovers are low but increasing as foreign penetration increases. After some point foreign penetration of the industry might start dampening the activities of local firms, which cannot compete with foreign affiliates any more and are forced to exit. This argumentation leads to an inverted U-shaped relationship between foreign penetration and horizontal spillovers, which in turn cannot be assessed correctly by applying linear estimators. Even if there is in fact a correlation between foreign penetration and horizontal spillovers, linear estimation techniques cannot take account of it.

Figure 1 shows the actual relationships between foreign penetration measured at the NACE-2 digit level (horizontal axis) and the average growth of firms in the analysed period (vertical axis) in ten transition economies. From these figures one clearly see that the above discussion does not necessarily apply to transition economies as there is revealed no much scope for horizontal spillovers. If any, the estimated impact of horizontal spillovers on local firms' TFP growth should be very low.

Insert Figure 1

On the other side, one may expect a much larger scope for backward vertical spillovers as strong foreign penetration of a particular industry, at least, does not crowd out local firm in other industries. Hence, a monotonic positive relationship between purchases by foreign affiliates and TFP growth of local firms in vertically linked industries is expected. Figure 2, indeed, reveal some scope for positive backward vertical linkages in Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovenia.

Insert Figure 2

The results of estimations of the model (11) do confirm above speculations. The results can be summarized into four basic findings. First, in 5 transition countries FDI were found to be an important vehicle of direct technology transfer to domestic firms. In Estonia, Hungary and Slovenia foreign affiliates grow much faster in terms of TFP as compared to local firms, while in Lithuania and Romania faster productivity growth is accounted in the majority owned foreign affilates only. Surprisingly, in Czech Republic and Poland foreig affiliates are shown to lag behind their domestic counterparts. Second, on the contrary to our expectations, significant (though fairly low) positive horizontal spillovers to domestic firms are revealed in Czech Republic, Poland, Romania and Slovakia. In Bulgaria only foreign affiliates are affected by these positive horizontal spillovers. It should go without saying that in none of the analyzed countries foreign affiliates are shown to exhibit significant crowding out effects for domestic firms. Third, in accordance to Figure 2, evidence on positive backward vertical spillovers is found in Czech Republic, Poland and Slovenia. In Bulgaria, only foreign affiliates can accrue for these backward spillovers, while in Lithuania and Latvia even negative backward spillovers for for foreign affiliates are detected. The latter finding might well be caused by very poor coverage of firms for these countries in our database. Four, direct FDI effects provide by far the most important productivity spillover for local firms, which is on average by some factor 50 larger than the impact of backward linkages of FDI and by factor 500 larger than the impact of horizontal spillovers.

Insert Table 3

In our second model we account for the innovation capability and absorption capacity of local firms for taking advantage of the spillovers that are around in the economy. In doing this, the model (11) has to be rewritten:

$$\begin{gathered} y_{it} = \rho y_{it-1} + \alpha k_{it} - \rho\alpha k_{it-1} + \beta l_{it} - \rho\beta l_{it-1} + \gamma n_{it} - \rho\gamma n_{it-1} \\ +\phi RD_{it} - \rho\phi RD_{it-1} + \chi HS_{it} + \theta HS_{it}RD_{it} + \upsilon VS_{it}^{B} + \tau VS_{it}^{B}RD_{it} \\ +\varepsilon ES_{it} + (\delta_t - \rho\delta_{t-1}) + e_{it} + (m_{it} - \rho m_{it-1}) \end{gathered} \tag{12}$$

Model (12) is estimated on a sample of local firms only. In order to account for the innovation capability of local firms present and lagged RD_{it} variables are included. The interaction terms $HS_{it}RD_{it}$ and $VS_{it}^{B}RD_{it}$ are included in order to account for the absorption capacity of local firms. Econometric approach is the same as above. A great portion of cautiosness is needed when we interprete the estimation results of this model. Data on firms' R&D stocks consist of the intangible assets variable contained in the firms' balance sheets. These variable, however, do not look very promising since it includes only a small portion of actual R&D investment of individual firms. In fact, the largest portion of R&D investments is contained in the material cost.

Insert Table 4

The results obtained by estimating (12) do not confirm the empahisized role of the innovation capability and absorption capacity of local firms in transition economies. Innovation capability as a source of firm's own TFP growth is shown to be important in least developed transition economies, such as Lithuania, Latvia and Romania, while in Hungary only lagged R&D investment seem to contribute to firm's TFP growth. Similarly, absorption capacity of local firms to take advantage of the spillovers is found to be important only in Slovakia, while in Estonia, Hungary and Latvia it is revealed to be even an obstacle to accumulation of potential horizontal spillovers of FDI. In terms of backward vertical spillovers, the absorption capacity of firms does not seem to have an effect on their TFP growth. The only exception being local firms in Slovenia and Romania, where higher absorption capacity tend to decrease the scope for accumulation of vertical spillovers from FDI. As discussed above, our failure to find some impact of the innovation capability and absorption capacity of local firms on their TFP growth might well be driven by the poor quality of the data on R&D at the firm level. On the other side, a study of Alverez et al (2002), which took account of the whole set of firms' actual technology measures stemming from national innovation surveys for Spain, also failed to find significant correlation between firm's innovation capability and its TFP growth as well between its absorption capacity and spillover effects.

6 Conclusions

The main objective of this paper is to provide a comparative study on importance of spillovers through FDI on a set of comparable countries by using a common methodology and up-to-date dynamic panel data techniques. This is the way how to achieve comparability of the results and to provide a credible insight into the importance of different channels of international technology transfer for firms in transition countries. In order to do this, the study differentiate between direct effects of FDI from the parent firm to local affiliates as well as horizontal vertical spillovers from foreign affiliates to domestically owned local firms. To calculate horizontal and vertical spillovers and to differentiate between backward and forward vertical linkages we use the methodology developed by Blalock (2001) and Damijan and Knell (2002). The importance of these different channels of technology transfer is then estimated in the framework of growth accounting approach using the unique firm level database consisting of some 8,000 firms for ten advanced transition countries in the period 1995-1999. Due to the simultanenity problem that typically arises in growth accounting approach estimated in the panel data framework, we make use of the recently developed econometric methods for dealing with dynamic panel data. Hence, we estimate augmented production function at the firm level using system general method of moments (sys-GMM) approach. In addition, we correct for potential selection bias that arises due to possibly endogenous foreign investment decisions using a generalized Heckman two-step procedure. We find that direct FDI effects are significant in five out of ten examined transition countries and that they provide by far the most important productivity spillover for local firms. Direct effects of FDI are found to provide on average an impact on firm's productivity that is larger by some factor 50 than the impact of backward linkages and by factor 500 larger than the impact of horizontal spillovers. On the other hand, vertical spillovers provide an impact on firm's productivity that is higher by factor 10 relative to horizontal spillovers. These results speak in favor of the larger importance of vertical versus horizontal spillovers from FDI.

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Appendix

Figure 1: Scope for horizontal spillovers -FIEs' penetration of industries and firms' average growth)

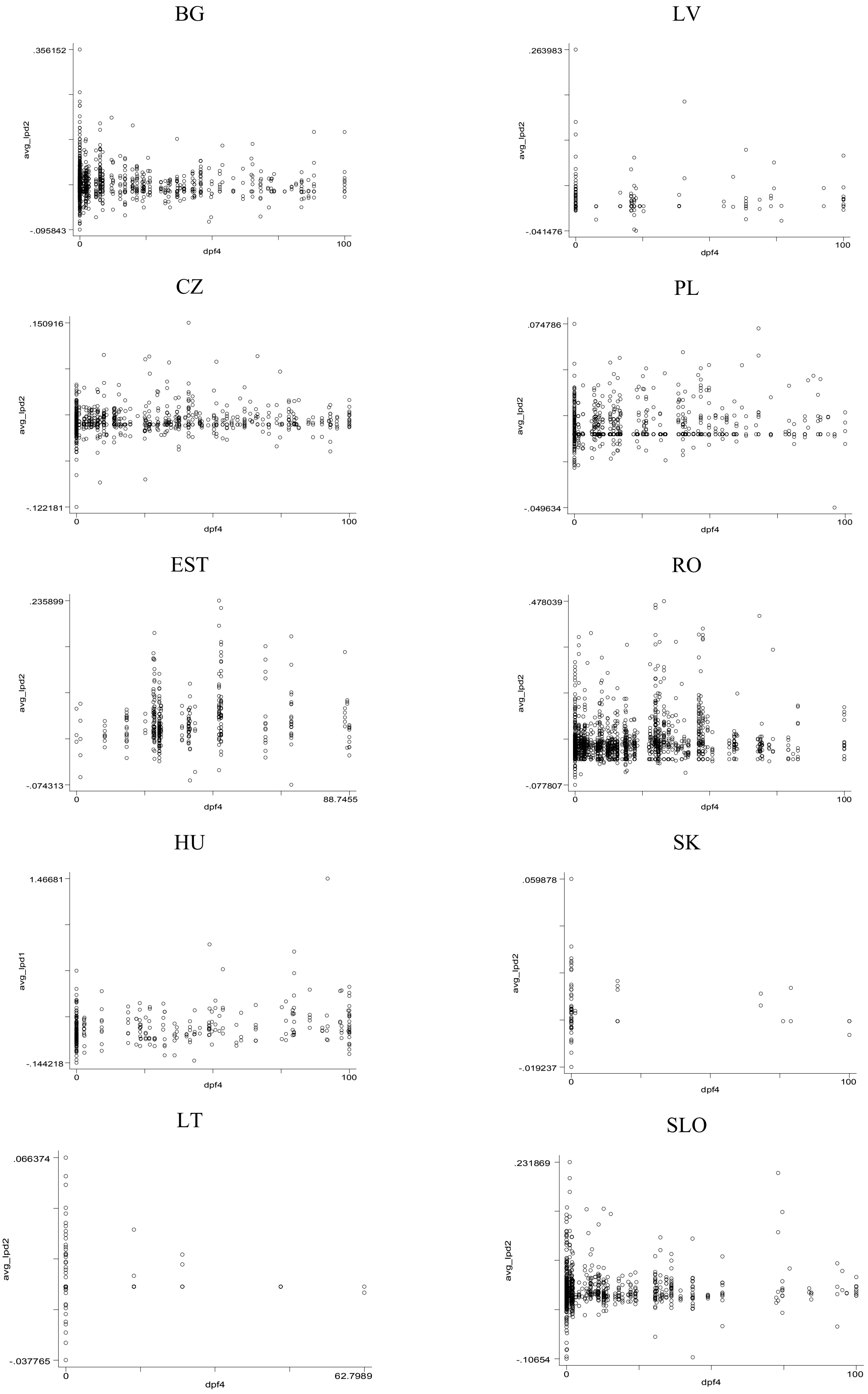

Figure 2: Scope for vertical spillovers - Backward linkages by FIEs and firms' average growth)

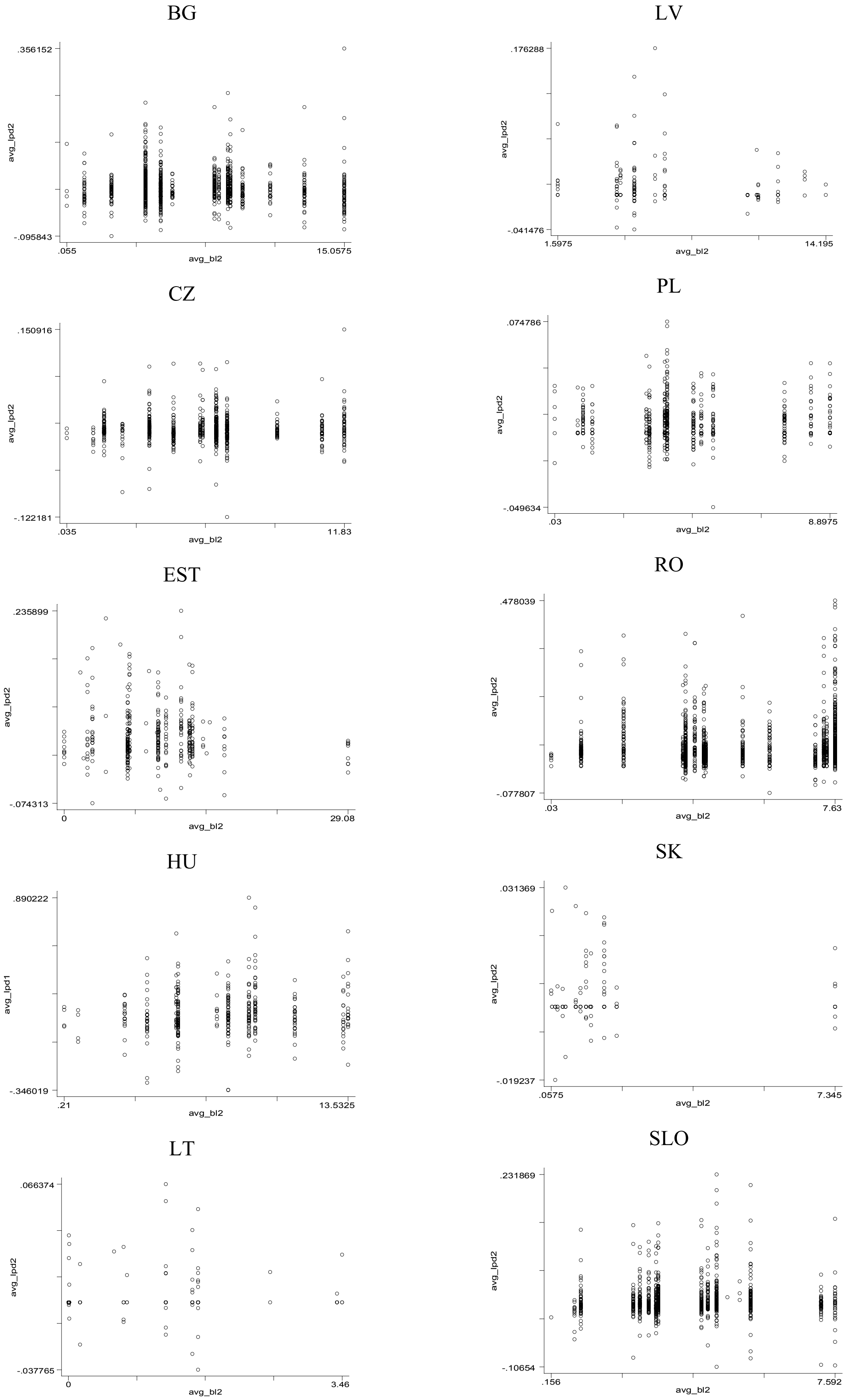

Table 1: Descriptive statistics for foreign vs. domestic manufacturing firms in 1999

	BG	CZ	EST*	HU	LT	LV	PL	RO	SK	SLO	Avg.
No. of all firms	1334	1168	373	360	171	194	1540	1711	151	1093	810
No. of FIEs	95	191	108	84	6	36	198	289	9	118	113
% of FIEs in no. firms	7.1	16.4	29.0	23.3	3.5	18.6	12.9	16.9	6.0	10.8	14.4
% of FIEs in sales	26.6	62.3	92.1	96.4	9.1	51.7	53.3	30.9	8.5	38.0	46.9
% of FIEs in emp.	15.2	30.0	56.0	48.9	3.4	31.6	18.8	19.4	6.2	17.3	24.7
% of FIEs in R&D	33.7	34.8	90.1	36.9	18.0	19.0	56.5	32.1	32.7	14.5	36.8
wage FIE / wage DE	1.73	1.34	1.41	1.31	1.00	1.00	0.74	1.21	1.25	1.16	1.22

* 1998 for Estonia

Table 2: Heckman two-stage sample selection: Probability of foreign investment decisions in 1995 (Results of probit model)

	BG	CZ	EST#	HU	LT	LV	PL	RO	SK	SLO
Size	-1.8E-07	1.2E-06	-3.4E-05	8.7E-07	-7.0E-05	8.1E-06	-1.8E-10	8.3E-07	-2.3E-06	3.7E-0
z-stat.	(-0.080)	(1.255)	(-1.627)	(0.440)	(-0.460)	(0.350)	(0.000)	(0.490)	(-0.540)	(1.294
Capital intensity	***0.019**	***0.003**	*****0.024**	***-0.004**	0.018	****0.072**	*****0.009**	****0.008**	0.004	-0.00
z-stat.	(1.854)	(2.180)	(3.457)	(-1.856)	(0.509)	(2.503)	(5.201)	(2.231)	(0.222)	(-0.70
Skill intensity	****0.216**	-0.015	0.080	***0.038**				-0.017	-0.056	****0.02**
z-stat.	(2.252)	(-1.237)	(1.002)	(1.769)				(-0.457)	(-1.135)	(2.436
Labor productivity	-0.001	-0.001	*****0.015**	0.001	-0.004	0.006	0.000	***0.002**	-0.009	7.2E-0
z-stat.	(-0.218)	(-0.784)	(2.648)	(1.531)	(-0.079)	(0.759)	(-0.363)	(1.667)	(-0.253)	(0.154
Sector size	****0.036**	0.015	0.002	0.018	0.005	0.007	0.011	-0.004	*****0.037**	-0.00
z-stat.	(2.210)	(1.589)	(0.250)	(1.581)	(0.119)	(0.262)	(0.973)	(-0.206)	(4.447)	(-0.584
Foreign penetration	*****0.024**	*****0.023**	*****0.012**	*****0.026**	****0.050**	*****0.031**	*****0.021**	*****0.025**	*****-0.026**	*****0.02**
z-stat.	(10.835)	(13.518)	(3.347)	(8.538)	(2.539)	(5.783)	(11.736)	(13.521)	(-4.056)	(8.488
Number of obs.	1334	1168	373	360	171	194	1540	1711	151	109
Pseudo R2	0.281	0.232	0.146	0.358	0.336	0.453	0.230	0.162	0.623	0.14

1994 for Estonia and Slovenia

Table 3: Impact of FDI: Direct effects and spillovers (Test 1)
(Sample of domestic and foreign owned firms)

Test1	BG	CZ	EST	HU	LT	LV	PL	RO	SK	SLO
FDI dummy	-0.027	***-0.126**	****0.162**	***0.070**	***-0.544**	-0.001	***-0.091**	***-0.050**	0.047	****0.052**
	(-0.99)	(-3.82)	(2.50)	(1.73)	(-2.69)	(-0.01)	(-2.92)	(-1.70)	(0.81)	(2.12)
Majority FDI	0.013	0.002	****0.041**	0.002	*****0.492**	0.015	-0.001	****0.015**	0.004	-0.002
	(1.07)	(0.20)	(2.16)	(0.14)	(4.82)	(0.76)	(-0.25)	(2.48)	(0.26)	(-0.37)
Hor_Spill	0.0001	*****0.0003**	-0.0004	0.0002	-0.0010	-0.0001	****0.0002**	*****0.0003**	***0.0006**	0.00004
	(0.69)	(2.67)	(-1.35)	(1.60)	(-1.24)	(-0.41)	(2.09)	(3.02)	(1.87)	(0.98)
Hor_Spill_FDI	***0.0007**	0.0002	0.0001	0.0003	-0.0076	0.0002	0.000002	0.0002	0.0003	-0.00001
	(1.79)	(1.40)	(0.25)	(0.89)	(-0.86)	(0.37)	(0.02)	(1.55)	(0.63)	(-0.08)
Backward_Spill	-0.001	*****0.003**	-0.001	-0.003	0.032	0.002	****0.002**	0.001	0.010	****0.001**
	(-0.94)	(2.65)	(-0.59)	(-1.31)	(1.40)	(1.25)	(2.29)	(0.83)	(0.29)	(2.21)
Backward_Spill_FDI	*****0.009**	0.002	0.002	0.000	***-0.984**	***-0.013**	0.002	0.000	-0.053	-0.002
	(2.59)	(0.60)	(0.90)	(0.01)	(-1.83)	(-2.74)	(0.63)	(0.11)	(-1.28)	(-0.94)
Forward_Spill	-0.001	***-0.005**	0.001	0.004	-0.006	-0.004	***-0.005**	0.000	-0.008	***-0.001**
	(-1.59)	(-3.64)	(0.30)	(1.17)	(-0.25)	(-1.50)	(-3.85)	(0.36)	(-0.26)	(-1.71)
Forward_Spill_FDI	**-0.009**	0.000	-0.001	0.001	***0.970**	****0.013**	0.001	0.001	0.032	0.001
	(-2.45)	(-0.07)	(-0.46)	(0.18)	(1.68)	(2.33)	(0.26)	(0.32)	(0.77)	(0.55)
Sector size	0.0003	0.0001	-0.0008	-0.0015	-0.0019	-0.0014	-0.0002	0.0002	***-0.002**	0.00001
	(0.81)	(0.19)	(-0.77)	(-1.52)	(-1.40)	(-1.58)	(-0.73)	(0.58)	(-3.21)	(0.20)
Sector size_FDI	**-0.0041**	***-0.0014**	0.0009	**-0.0035**	***0.0320**	-0.0004	-0.0010	-0.0001	0.0004	0.00003
	(-2.10)	(-1.67)	(0.66)	(-2.25)	(1.70)	(-0.20)	(-1.29)	(-0.09)	(0.14)	(0.28)
No. of obs.	4123	3985	1047	760	422	555	4271	6018	426	5170
AR(1)	-10.62	-5.68	-6.28	-2.31	-2.71	-2.63	-7.37	-10.82	-2.05	-10.20
AR(2)	0.08	-0.40	-	-	1.30	0.17	0.26	-1.68	-0.80	0.55

Table 4: Impact of R&D: Importance of innovative and absorptive capacity (Test 2)
(Sample of domestic firms only)

Test2	BG	CZ	EST	HU	LT	LV	PL	RO	SK	SLO
R&D	0.021	0.001	-0.006	-0.005	***0.115**	*****0.015**	0.000	***0.009**	****-0.011**	-0.002
	(0.98)	(1.60)	(-0.40)	(-1.48)	(1.88)	(2.98)	(0.21)	(1.70)	(-2.09)	(-0.92)
R&D(-1)	-0.024	-0.001	0.017	***0.016**	-0.069	***-0.011**	0.000	-0.009	0.009	0.005
	(-1.05)	(-1.60)	(0.67)	(1.68)	(-0.82)	(-1.82)	(-0.10)	(-1.57)	(1.49)	(1.46)
Hor_Spill	-0.0001	-0.0001	0.0001	0.0001	-0.0011	-0.00004	0.0001	****0.0001**	-0.0004	0.0001
	(-0.79)	(-0.81)	(0.21)	(0.32)	(-1.45)	(-0.21)	(1.57)	(2.45)	(-1.05)	(1.41)
Hor_Spill_R&D	4.6E-05	-2.8E-07	****-0.0001**	****5.4E-05**	3.3E-04	***-5E-06**	4.9E-06	4.3E-07	****0.0004**	-3.8E-06
	(1.24)	(-0.55)	(-2.24)	(2.18)	(0.75)	(-1.80)	(0.59)	(0.56)	(2.31)	(-0.51)
Backward_Spill	-0.001	*****0.004**	-0.001	-0.0002	0.014	0.002	****0.002**	0.0004	-0.009	*****0.002**
	(-1.18)	(2.74)	(-0.58)	(-0.06)	(0.54)	(0.84)	(2.28)	(0.59)	(-0.34)	(2.95)
Backward_Spill_R&D	-0.0004	0.00001	0.0002	-0.0004	0.010	0.0001	0.00002	***-0.0001**	-0.002	****-0.0002**
	(-0.86)	(0.50)	(0.46)	(-0.76)	(0.47)	(0.71)	(0.16)	(-1.83)	(-0.86)	(-2.06)
Forward_Spill	-0.001	*****-0.005**	0.002	0.003	0.012	-0.002	*****-0.005**	0.001	0.006	***-0.001**
	(-1.22)	(-3.40)	(0.98)	(0.76)	(0.52)	(-0.67)	(-4.02)	(1.01)	(0.24)	(-1.89)
Forward_Spill_R&D	0.0003	-0.00001	0.00003	-0.00002	-0.014	***-0.0002**	-0.0001	***0.0001**	0.005	0.0001
	(1.02)	(-0.49)	(0.09)	(-0.06)	(-0.64)	(-1.69)	(-0.61)	(1.71)	(1.31)	(1.28)
Sector size	0.0001	-0.0004	-0.001	*****-0.002**	****-0.002**	-0.001	-0.001	0.0001	*****-0.003**	-0.00001
	(0.18)	(-1.44)	(-0.82)	(-2.62)	(-2.11)	(-1.23)	(-1.62)	(0.34)	(-4.45)	(-0.40)
Sector size_R&D	0.0001	2.5E-08	-0.0005	-3.2E-05	-0.0006	***-0.0001**	****0.0001**	3.3E-05	-2.8E-05	9.8E-07
	(0.46)	(0.61)	(-0.85)	(-0.31)	(-1.63)	(-1.77)	(2.28)	(0.98)	(-0.94)	(0.33)
No. of obs.	3820	3308	759	583	411	438	3712	5075	398	4633
AR(1)	-9.99	-4.49	-4.91	-2.72	-2.73	-3.36	-7.71	-8.94	-1.79	-9.69
AR(2)	0.44	-0.17	-	-	1.30	0.61	-1.00	-1.82	-1.27	0.54